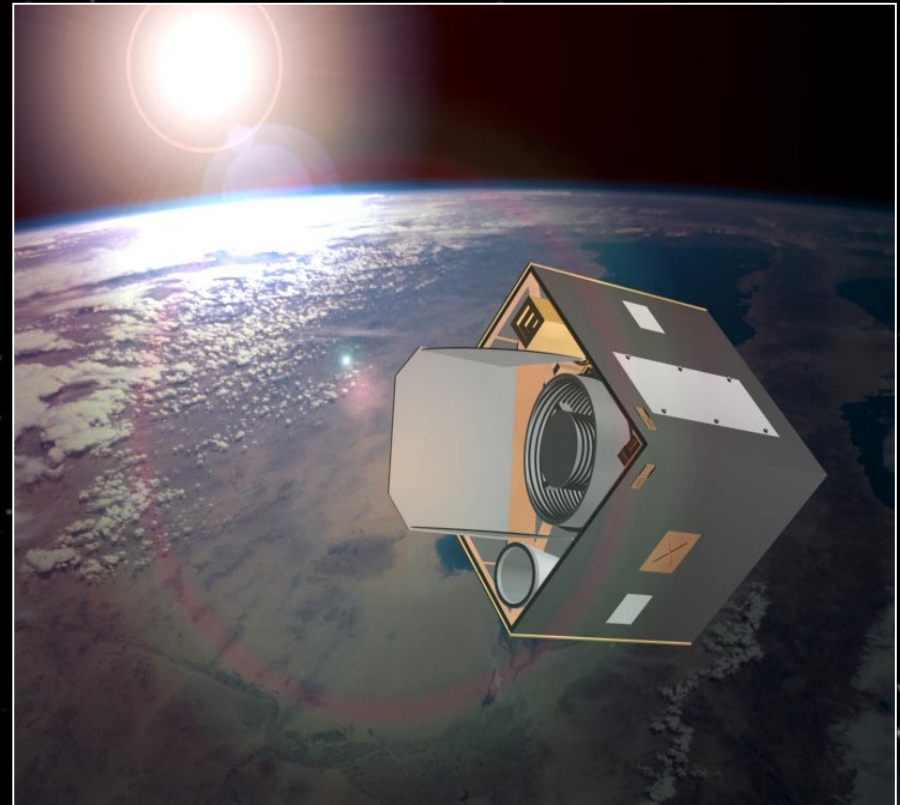


Example 2- Rømer Satellite Mission

- **Introduction.**
- **Mission boundary conditions incl.**
 - Political boundaries
 - Other boundaries
 - Cost and funding
- **Rømer Mission Analysis**
 1. Science Requirements
 2. Required Payload
 3. Orbit
 4. Launch vehicle
 5. Setting the Satellite Basic constraints
 6. Defining the more detailed technical constraints





Introduction

1. **RØMER is not an ESA mission**
2. **RØMER has to be in line with the political, financial and industrial boundary conditions within Denmark**
3. **RØMER is a small, low cost satellite with only one Payload.**
4. **RØMER satellite development and success relies on a strongly focused science mission and TEAM effort.**
5. **RØMER mission has to take certain measured risks to stay within the boundary conditions.**



Example 2 - Boundary conditions – political boundaries

PRIMARY

- High scientific profile with Danish center of excellence and a high degree of Danish Involvement (both industry and universities).
- An “affordable” cost in relation of the Ørsted mission cost (*Danish governmental contribution*). Hence LOW COST.

SECONDARY

- Mission shall provide close corporation between industry, universities and research organizations.
- Mission shall enable a high level of educational & public outreach on all levels.
- Mission should preferably have relation to ESA programme (s).

SUCCESS CRITERIA: World class science



Boundary conditions – other boundaries

PRIMARY

- **Co-funding by industry shall be oriented towards development of relevant products and technologies.**

SECONDARY

- **Mission shall function as a development platform for new technologies.**
- **Flight opportunity and hence flight heritage for new products**
- **Centralized design (Satellite in a box concept & high degree of SW control)**
- **Mission shall enable the possibility for “Miniaturization”**
- **Platform/payload should be separated to enable reuse of platform as much as possible.**

SUCCESS CRITERIA: World class science, New developments, New contracts



Boundary conditions – Financial boundaries

1. **Project Cost (complete mission life) comparable to Ørsted Mission**
2. **Main funding to come from new four-year extension of Small Satellite Programme**
3. **Additional funding to come from other ministries, institutions, industry and private funds**



Rømer Mission Analysis - Science requirements

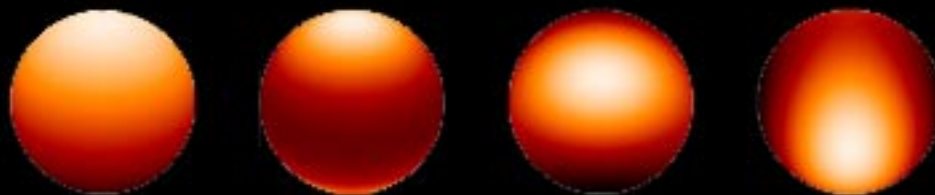
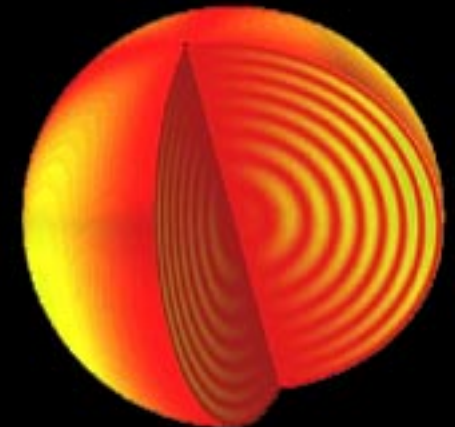
Primary

Measuring Oscillations in Nearby Stars – MONS....Measurement of intensity and colour oscillations in solar-like stars, to probe the stellar interior for determination of its composition, age, mixing and internal rotation.

Secondary

Secondary science is only implemented in the satellite design to the extent possible within the available on-board margins. Science may include discovery of extra-solar planets through the effects of transits across the stellar disk, detection of supernova explosions in distant galaxies and discovery of asteroids in our solar system.

Ex 1: Single Mode Oscillation



**Variation of
Stellar Oscillation
Amplitudes**

**PI: Jørgen Christensen-Dalsgaard (jcd@obs.aau.dk)
Institute of Physics and Astronomy/Theoretical Astrophysics Center, Aarhus University**

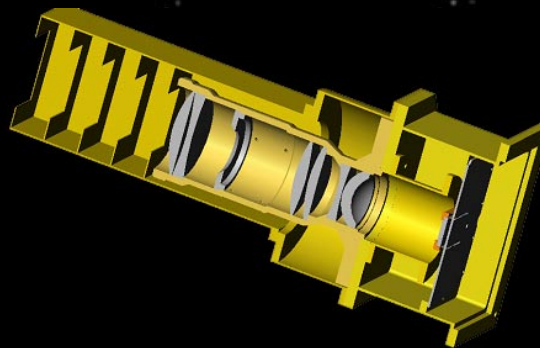
Rømer Mission Analysis – Required Payload

The primary science instruments include:

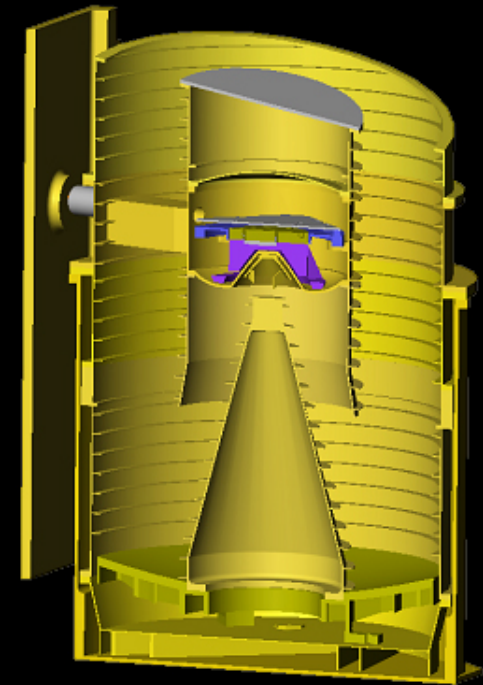
- MONS Telescope having a 32 cm aperture, equipped with a high-precision photometric CCD detector for measuring oscillations of stellar intensity and colour
- MONS Field Monitor for examining the field of view of the MONS Telescope for faint variable stars

The secondary science instruments include:

- Forward- and aft-looking Star Trackers of the Attitude Control Subsystem, to be used for studying variable stars
- The MONS Field Monitor



Field Monitor



MONS Telescope



Candidate RØMER Orbits Considered

- **Geostationary Orbit (GEO) (35786 km, 0°, 23^h56^m)**
Requires apogee kick motor and propulsion system for momentum dumping
- **Geostationary Transfer Orbit (GTO) ($\approx 500 \times \approx 36000$ km, 7°, 10.6^h)**
High radiation environment, drift of line of apsides unacceptable w.r.t. communication
- **Orbit of the Global Positioning System (GPS) satellites (20184 km, 55°)**
Very high radiation environment not useful for observations,
Requires apogee kick motor and propulsion system for momentum dumping
- **Transfer orbit of the Global Positioning System (GPS) satellites ($\approx 400 \times \approx 20000$ km, 55°)**
Very high radiation environment not useful for observations
- **Inclined, deep elliptical orbits (e.g. XMM/Newton, AXAF/Chandra etc.)**
Requires propulsion system for momentum dumping due to high perigee
No launch available in desired time frame
- **Molniya orbit ($\approx 500 \times \approx 40000$ km, 63.4°, 11^h58^m)**
Satisfies all observational requirements
Allows momentum dumping based on magnetorquers
- **Tundra orbit ($\approx 24500 \times \approx 47000$ km, 63.4°, 23^h56^m)**
Requires apogee kick motor (TBC) and propulsion system for momentum dumping



Rømer Mission Analysis - Orbit

The Molniya orbit was selected as the current baseline for RØMER

Largest separation from Earth (Apogee): Approx. 40000 km

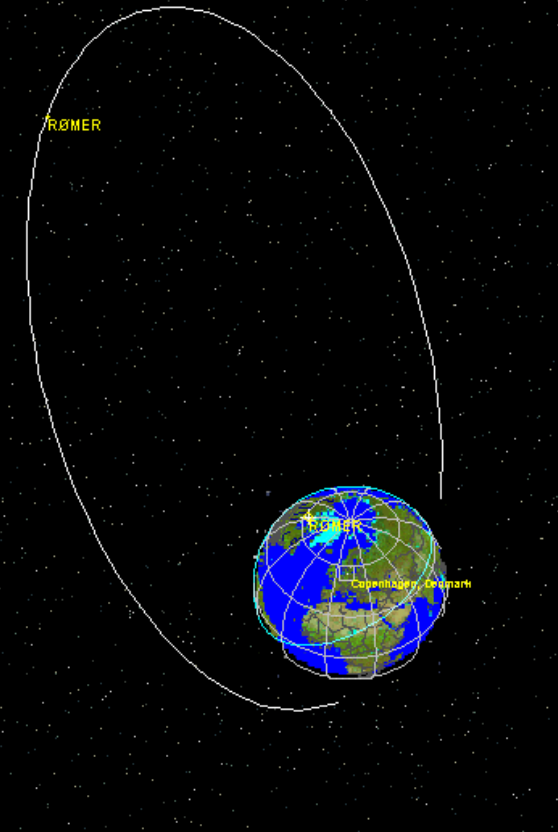
Smallest separation from Earth (Perigee): Approx. 600 km

Angle between orbit and Equator (Inclination): 63.4°

Period: 11 hours 58 min. 02 sec. (= 1/2 sidereal day, ideal)

The Molniya orbit allows approx. 10 hours of observations outside the radiation belts.

A satellite in Molniya orbit is subjected to a large dose of radiation from high-energy protons and electrons trapped in the Earth's radiation belts.



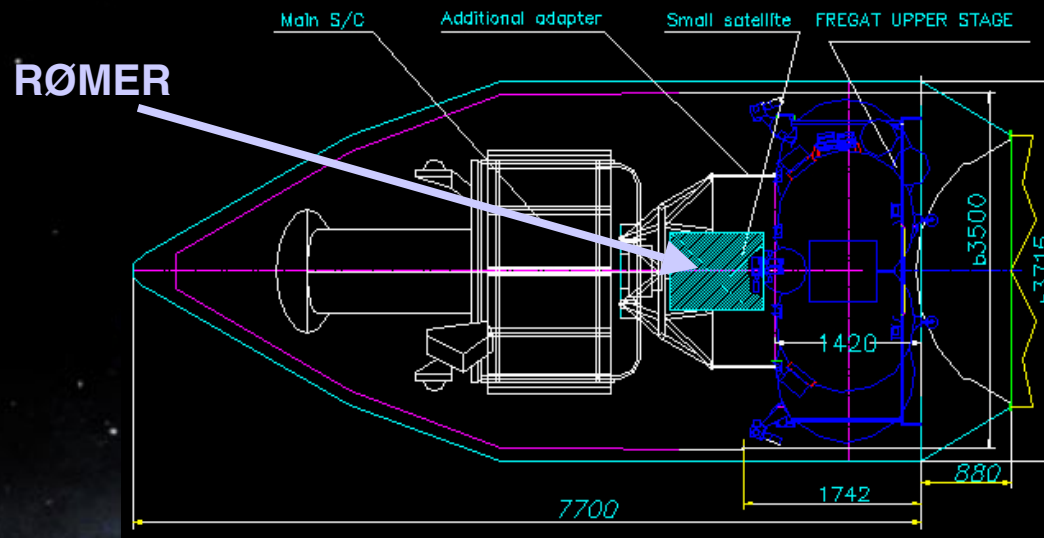
Rømer Mission Analysis - Launch

RØMER is foreseen to be launched with a Russian SOYUZ/FREGAT rocket end 2005.

The SOYUZ rocket has been launched more than 1650 times and its reliability exceeds 97%

FREGAT is a new upper stage developed by Lavochkin Association, which has been qualified by two launches 09 February and 20 March 2000 with great success. (Cluster II)

RØMER will use the Ariane 5 ASAP separation system



Rømer Mission Overview – Satellite Basic constraints

Dimensions: 60 x 60 x 71 cm

Mass: ≈100 kg

Power Consumption: ≈55 W orbit average

Radio Transmitter: 2 W, S-Band (2200 - 2290 MHz)

Downlink Data Rate: 500 - 64000 bit/s

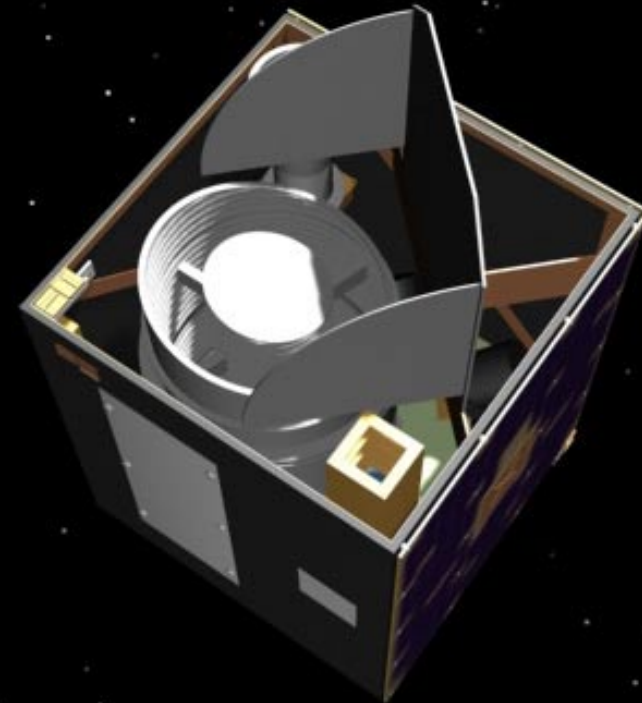
Downlink Transmission Capacity:
Min. 24 Mbyte/day

Uplink Data Rate: 500 and 4000 bit/s

Pointing Accuracy at 95% confidence:

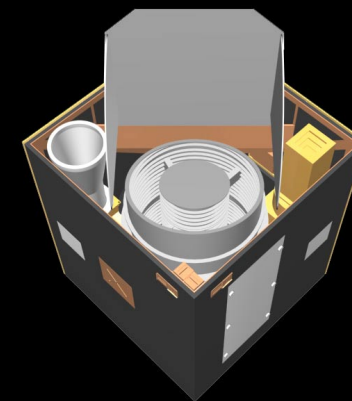
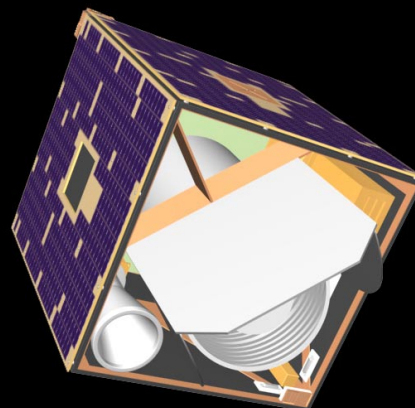
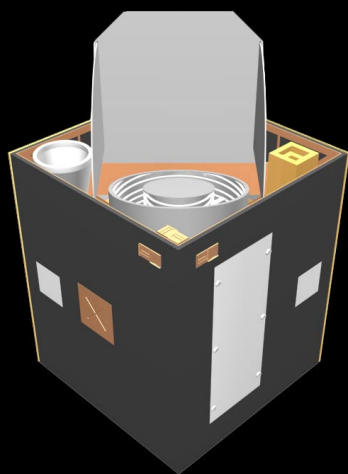
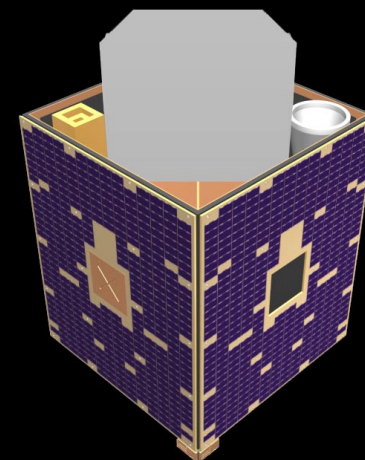
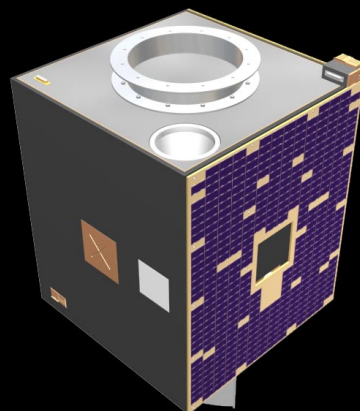
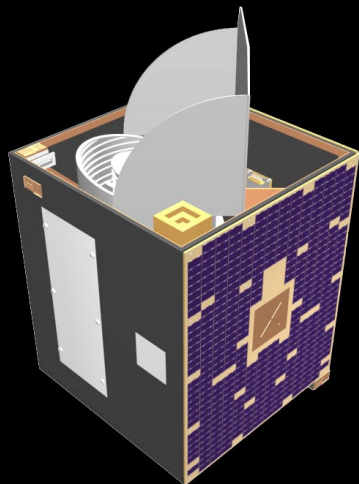
Pitch/Yaw: 2 arcmin absolute
0.8 arcmin over 1 sec.
0.35 arcmin over 0.1 sec.

Roll: 60 arcmin absolute
2 arcmin over 60 sec.





Rømer Mission Analysis – Satellite Different Views



Rømer Mission Overview – Satellite Electrical Configuration

